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INCLUDING PRESTRESSED CONCRETE

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LEADING CONTENTS

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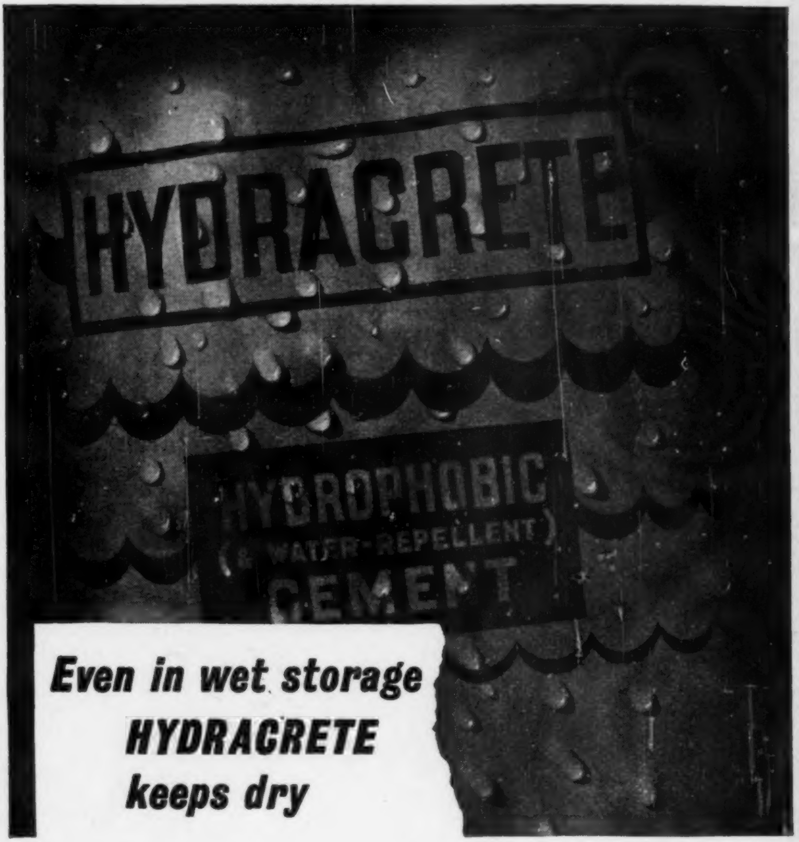
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CONCRETE
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INCLUDING PRESTRESSED CONCRETE

Volume LIII, No. 4. LONDON, APRIL, 1958.

EDITORIAL NOTES

"Mr. Engineer Smith."

As part of the campaign of the Engineers' Guild to " improve the status " of engineers, a meeting was held recently by the Midlands Branch to discuss the " regulation " of the description engineer with a view to " maintaining the status of the professional engineer at a high level ". One of the speakers was a lecturer at Birmingham University, who is reported to have said, " In Germany a professional engineer, by long-standing custom, was addressed as Mr. Engineer Schmidt ; even his wife would be addressed as Mrs. Engineer Schmidt. While this might sound strange, it reflected the high social status given to the engineer in Germany, a status that had assisted and encouraged the remarkable technological progress in that country, particularly in post-war years."

" Mr. Engineer Schmidt " would indeed sound as strange in Germany as would " Herr Ingenieur Smith " in this country. But how naive it is to claim that in Germany the engineering profession is able to make remarkable technological progress merely because those engaged in it ensure that their neighbours and correspondents know that they are engineers and that their wives' friends and acquaintances know that these ladies are married to engineers. And why should this self-advertisement have resulted in remarkable technological progress in Germany " particularly in post-war years ", for in Central Europe it was the custom to indicate an engineer's profession in this way long before the war.

It is possible that if engineers were to single themselves out from the rest of the community in this way there would be jealousies within the profession when it was discovered that Mr. Engineer Smith who had just left college was indistinguishable from Mr. Engineer Smith who was a leader of the profession. They might then be tempted to adopt the Central European idea in its entirety, and let the public know the relative importance of engineers by titles similar to the German Dr.-Ing., Dipl.-Ing., Oberregierungsbaurat Dipl.-Ing., Senatsrat Dipl.-Eng., Prov. Oberaurat Dipl.-Eng. Schmidt, and so on. An uninterested public would then know the examinations that the gentlemen had passed and their particular spheres of activity. It would also no doubt be desirable to distinguish between Mr. Practising Engineer Smith, Mr. Lecturer Engineer Smith, Mr. Civil-servant Engineer Smith, and so on, so that the public would have some idea of the relative amount of esteem and adulation due to each of them.

It seems to be overlooked that the Associated Society of Locomotive Engineers and Firemen and the Amalgamated Engineering Union were formed before most of the members of the Guild were born. Why this belated anxiety about the possibility that a professional engineer be mistaken for a train driver or a mechanic ?

The idea of some members of the Guild seems to be : This is an engineers' world. Therefore engineers are the most important members of the community, engineers should be held in greater esteem than lesser people in other walks of life, engineers should have a greater part in directing the affair of nations, and if engineers were held in more esteem they would be better engineers. From this jumble of false reasoning based on false premises it is claimed that greater public esteem is the only means of obtaining greater progress in engineering. Better teaching by better teachers is not mentioned. More concentration on study while at college and afterwards is ignored. The only claim made is that when all and sundry know that a man is an engineer he will become a better engineer with no more effort on his part.

Much is made of the fact that many manual workers have abandoned the honourable title mechanic and that many of them call themselves engineers, and the Guild recommends that we copy the United States and use the term professional engineer to distinguish those who design from those who work with their hands. This form of snobbery is not seen in other professions. Many men engaged in clerical and mechanical work in the Royal Air Force have the title Pilot Officer, Flight Lieutenant, Squadron Leader, and even Air Commodore although they have never learnt to fly an aeroplane, but we have not heard qualified pilots object to the use of these titles by men whose work is on the ground. Neither have we heard doctors of divinity and of medicine complain of the use of this title by the ever-increasing number of doctors of philosophy—another fairly recent import from Central Europe.

Why cannot the members of the Guild, in their craving for public esteem, think of something original instead of copying Central European and American ideas ? It might be suggested, for example, that engineers wear a miniature slide-rule in the lapel of their jackets. A member of the would-be ruling class would then be easily recognisable, and lesser folk could show their esteem by bowing on passing. Is it assumed that recognition of a high social status would send the engineer back to his office with new ideas and greater vigour, and, thus "assisted and encouraged", produce in Britain even greater technological progress than the speaker credited to the Mr. Engineer Schmidts ? Or is this all nonsense, and unworthy of a great profession ? If it were as simple as this the progress of the whole nation could be hastened if everyone used the name of his profession or trade as his first forename. Would Mr. Smith be a better architect if he were known as Mr. Architect Smith, Mr. Jones a better builder when he became Mr. Builder Jones, and Mr. Robinson a better surveyor if he were known as Mr. Surveyor Robinson ? Is not a man likely to be a better engineer if he pursues engineering for its own sake, rather than with an eye to the amount of adulation he receives from his fellow men ? The speaker is reported to have claimed that unless "the professional group is able to detach itself from the rest" the result will be "a low average level ending with mediocre status". We do not believe it.

Circular Reinforced Concrete Columns.

A Load-factor Method of Design.

By R. J. BARTLETT.

THE load-factor method of designing rectangular columns* may be extended to include circular columns. For an unreinforced section of diameter D (*Fig.* 1), if the load W producing failure has an eccentricity e the effective load-bearing part of the section is a segment ACB with its centre of area J a distance e from the centre O. The depth of the neutral axis n will be the depth HC of this segment. From the trigonometry of segment ACB,

$$n = \frac{D}{2}(1 - \cos\alpha) = ND.$$

The area of ACB is $\frac{D^2}{4}(\alpha - \sin\alpha\cos\alpha) = \frac{4D^2K}{3}$. The moment of the area ACB about the centre O is

$$\frac{D^3}{12}\sin^3\alpha = \frac{D^3G}{7{\cdot}5}, \text{ and } e = \frac{D\sin^3\alpha}{3(\alpha - \sin\alpha\cos\alpha)} = ED$$

in which 2α is the angle subtended at the centre by the arc ACB, and N, K, G, and E represent expressions containing trigonometrical functions of α. Curves giving the relationships between K and the other three coefficients are given in *Fig.* 2.

As in the case of rectangular sections, if the value of an applied working load P multiplied by a load-factor of safety of two is less than the strength of the whole section $C_{max.}$ assuming that the stress in the concrete is half the

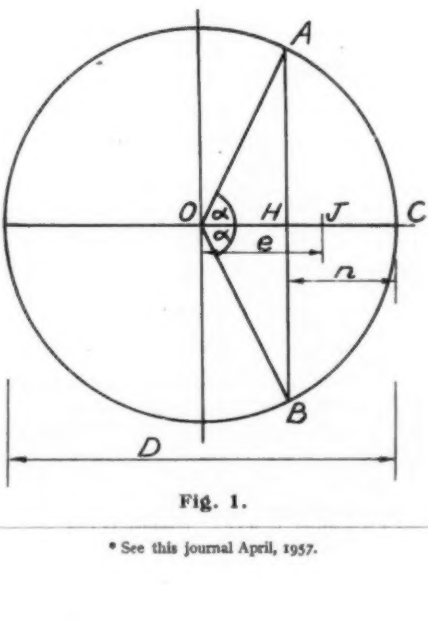


Fig. 1.

* See this journal April, 1957.

crushing strength u at 28 days, eccentricity may occur before reinforcement becomes theoretically necessary.

Then $2P = \frac{u}{2} \times \text{area ACB} = \frac{3c}{2} \times \frac{4D^2K}{3}$.

Therefore $$P = cD^2K \qquad . \quad . \quad . \quad . \quad . \quad (1)$$

in which c is the normal maximum permissible working stress in concrete in bending.

For this load P the maximum permissible eccentricity is given by

$$e = ED \qquad . \quad . \quad . \quad . \quad . \quad (2)$$

and the depth of the neutral axis by $n = ND$ . . . . . (3)

If P, c, and D are known, K is calculated from (1). The corresponding values of E and N are then read from *Fig.* 2, and the values of e and n are found by substituting in (2) and (3) respectively. It follows that if e, c, and D are known, the maximum value of P can be calculated.

EXAMPLE I.—A circular column of 12 in. diameter is to support a working load of 30,000 lb. Calculate the maximum permissible bending moment if c is 1000 lb. per square inch.

From (1), $K = \frac{P}{cD^2} = \frac{30,000}{1000 \times 12^2} = 0{\cdot}2083$. From *Fig.* 2, $E = 0{\cdot}275$ and $N = 0{\cdot}384$; therefore $e = 0{\cdot}275 \times 12 = 3{\cdot}3$ in. Therefore the maximum permissible bending moment is $30,000 \times 3{\cdot}3 = 99,000$ in.-lb. If the applied moment does not exceed this value, a nominal amount of reinforcement only is required.

Similarly, if M is the working moment applied to the column,

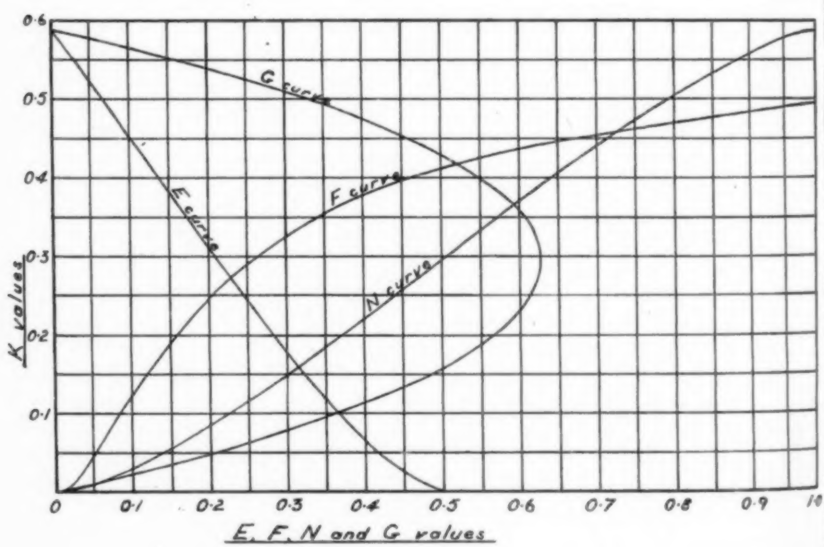


Fig. 2.

$$2M = \frac{u}{2} \times \text{moment of area ACB} = \frac{3c}{2} \times \frac{D^3G}{7{\cdot}5}.$$

Therefore $$M = \frac{cD^3G}{10} \qquad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

If M, c, and D are known, G can be calculated from (4) and the corresponding value of K read from *Fig.* 2. The maximum and minimum permissible loads P can then be obtained from equation (1).

EXAMPLE II.—A circular column of 12 in. diameter is to resist a working bending moment of 90,000 in.-lb. Calculate the maximum and minimum permissible loads if c is 1000 lb. per square inch.

From (4), $G = \dfrac{10 \times 90{,}000}{1000 \times 12^3} = 0{\cdot}521$. From *Fig.* 2, $K = 0{\cdot}17$ and $0{\cdot}417$.

Therefore

$P = 1000 \times 144 \times 0{\cdot}17 = 24{,}500$ lb., and $1000 \times 144 \times 0{\cdot}417 = 60{,}000$ lb.

If the applied load lies between these values, nominal reinforcement only is required.

Equations (1) and (2) can be combined to eliminate D and give $\dfrac{P}{ce^2} = \dfrac{K}{E^2}$.

If $\dfrac{K}{E^2}$ is represented by $100F^2$, then

$$F = \frac{1}{10e} \times \sqrt{\frac{P}{c}} \qquad . \quad . \quad . \quad . \quad . \qquad (5)$$

If P, c, and e are known, F can be calculated from (5) and the value of K read from *Fig.* 2. By substituting the values of P, C, and K in equation (1), the minimum diameter required can be calculated. The reinforcement in such a column would be nominal in amount.

EXAMPLE III.—A circular column is to resist a working load of 20,000 lb. and a bending moment of 50,000 in.-lb. If c is 1000 lb. per square inch, calculate the minimum diameter of the column.

$$e = \frac{M}{P} = \frac{50{,}000}{20{,}000} = 2{\cdot}5 \text{ in.}$$

From (5), $$F = \frac{1}{10 \times 2{\cdot}5} \times \sqrt{\frac{20{,}000}{1000}} = 0{\cdot}179.$$

From *Fig.* 2, $K = 0{\cdot}223$. From (1), $20{,}000 = 1000 \times D^2 \times 0{\cdot}223$.

$$D = \sqrt{\frac{20}{0{\cdot}223}} = \sqrt{90} = 9{\cdot}5 \text{ in.}$$

If in a particular case the actual eccentricity e_1 exceeds the value of e given by (1) and (2), the excess moment must be resisted by reinforcement, which would normally comprise an even number of bars of similar size symmetrically arranged about the centre of the column. When the column fails the strain in each bar will depend on its distance from the neutral axis. The stress in each bar will vary similarly to a maximum, which is the yield stress t_y for mild steel, or whatever value may be considered suitable for other types of steel.

To calculate the amount of reinforcement required in a circular column, an approximate design must first be made and then modified to agree reasonably with conditions at failure, allowing for a load-factor of two. The cross section of a column of diameter D reinforced with eight mild steel bars is shown in *Fig.* 3(*a*), and NN′ is the neutral axis. Initially the values of *e* and *n* are calculated, using equations (1), (2), and (3) and *Fig.* 2, and then modified as described later. A steel stress-variation diagram, *Fig.* 3(*b*) is then constructed to a fairly large scale as follows.

Draw AB equal to *D*, cutting the neutral axis at right-angles at C. Through

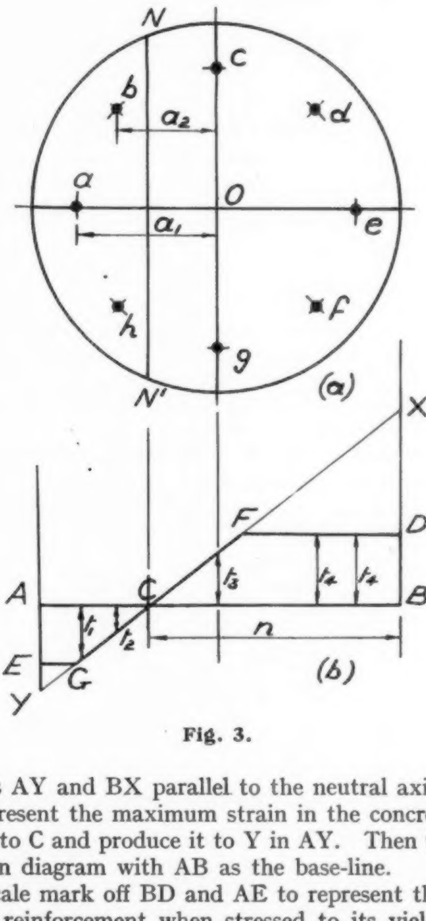


Fig. 3.

A and B draw lines AY and BX parallel to the neutral axis. To a convenient scale make BX represent the maximum strain in the concrete of 0·33 per cent. at failure. Join X to C and produce it to Y in AY. Then the straight line XY represents the strain diagram with AB as the base-line.

To the same scale mark off BD and AE to represent the strain of 0·12 per cent. in mild steel reinforcement when stressed to its yield point. Draw DF and EG parallel to AB and cutting XY at F and G respectively. To a different scale, DFCGE represents the stress-diagram for the steel with AB as the base-line, and BD and AE represent the yield-stress in the reinforcement.

The stresses in the bars in *Fig.* 3(*a*) can be scaled from *Fig.* 3(*b*) according to their distances from the neutral axis; the stress in bar a will be t_1, in bars b and h it will be t_2, and so on. Calculating the moments about the centre O of the section, the moment of resistance of the bars is

$$At_1a_1 + 2At_2a_2 + 2At_3a_2 + At_4a_1 = A(t_1a_1 + 2t_2a_2 + 2t_4a_2 + t_4a_1) = A \times \Sigma at$$

in which A is the unknown area of each bar. By equating this expression to the excess applied moment, the area of the bars can be calculated.

Except when the neutral axis passes through the centre of the column, this solution is inaccurate because the direct internal forces and external load do not balance. The inaccuracy increases as the distance of the neutral axis from the centre increases. When the area of reinforcement has been calculated the sum of the internal forces should be compared with the applied load, and if they differ considerably the value of n should be modified and the problem worked again from the beginning, using new values for the load and the moment resisted by the concrete. It is not necessary that the balance of forces should be exact, as the theory from which the method is derived is based on an approximation to the true conditions for failure.

If n is less than $\frac{1}{2}D$ the sum of the internal forces will be less than the load $W(= 2P)$ at failure; the original value of n should therefore be increased and the diagram for the stress in the steel modified accordingly. The amount cannot be expressed conveniently by a formula; a value should be assumed and modified subsequently if necessary. The addition to n varies from zero to a maximum depending upon the magnitude of the excess moment and the value of $\frac{1}{2}D - n$. If n is greater than $\frac{1}{2}D$ the sum of the internal forces will be greater than W, and n must be decreased, using the same method as before.

EXAMPLE IV.—A circular reinforced concrete column is to resist a working load of 60,000 lb. and a bending moment of 240,000 in.-lb. If c is 1000 lb. per square inch and the diameter of the column is 12 in., calculate the reinforcement required using mild steel bars with $1\frac{1}{2}$ in. (minimum) cover.

From (1), $K = \dfrac{60{,}000}{1000 \times 12^2} = 0{\cdot}417$. From *Fig.* 2, $E = 0{\cdot}124$, and $N = 0{\cdot}666$.

The moment on the concrete

$$= 0{\cdot}124 \times 12 \times 60{,}000 = 90{,}000 \text{ in.-lb. (approx.)}.$$

The moment on the reinforcement $= 240{,}000 - 90{,}000 = 150{,}000$ in.-lb.

If eight bars are arranged with their centres 2 in. from the surface, the stress diagram will be as shown in *Fig.* 4.

$$A \times \Sigma at = A(4 \times 18{,}000 + 2 \times 2{\cdot}83 \times 18{,}000 + 4 \times 13{,}000 + 2 \times 2{\cdot}83 \times 5400)$$
$$= A \times 256{,}300.$$

Equating this to the moment to be resisted by the reinforcement,

$$A \times 256{,}300 = 150{,}000.$$

Therefore $A = 0{\cdot}585$ sq. in.

Reducing n to 7 in. and modifying the stress-diagram,

$$N = \frac{7}{12} = 0{\cdot}583,\ E = 0{\cdot}166, \text{ and } K = 0{\cdot}357.$$

The load on the concrete is $1000 \times 144 \times 0{\cdot}357 = 51{,}400$ lb. The moment

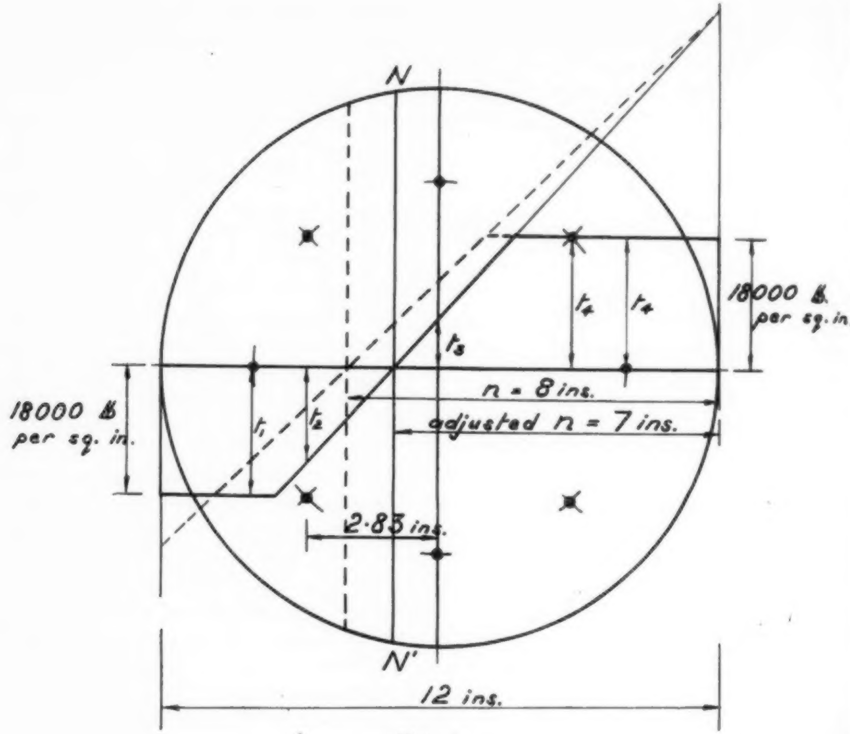


Fig. 4.

on the concrete = 51,400 × 12 × 0·166 = 102,400 in.-lb. The moment on the reinforcement = 240,000 − 102,400 = 137,600 in.-lb.

$$A \times \Sigma at = A(2 \times 4 \times 18{,}000 + 2 \times 2{\cdot}83 \times 18{,}000 + 2 \times 2{\cdot}83 \times 13{,}200)$$
$$= A \times 320{,}800 = \text{moment on reinforcement.}$$

Therefore $A \times 320{,}800 = 137{,}600$, and $A = 0{\cdot}43$ sq. in.

The internal forces are:

Compression in concrete		= 51,400 lb.
Compression in reinforcement	= 3 × 18,000 × 0·43	= 23,200 lb.
	2 × 6500 × 0·43	= 5,600 lb.
		80,200 lb.
Less tension in reinforcement	= 2 × 13,000 × 0·43 } 1 × 18,000 × 0·43 }	= 19,000 lb.
		61,200 lb.

This is sufficiently near to the load of 60,000 lb. to be acceptable. Therefore, eight bars, each 0·43 sq. in. in area, would be sufficient.

When the first value of *n* calculated indicates that the neutral axis is a considerable distance from the centre O, and the moment to be resisted by reinforce-

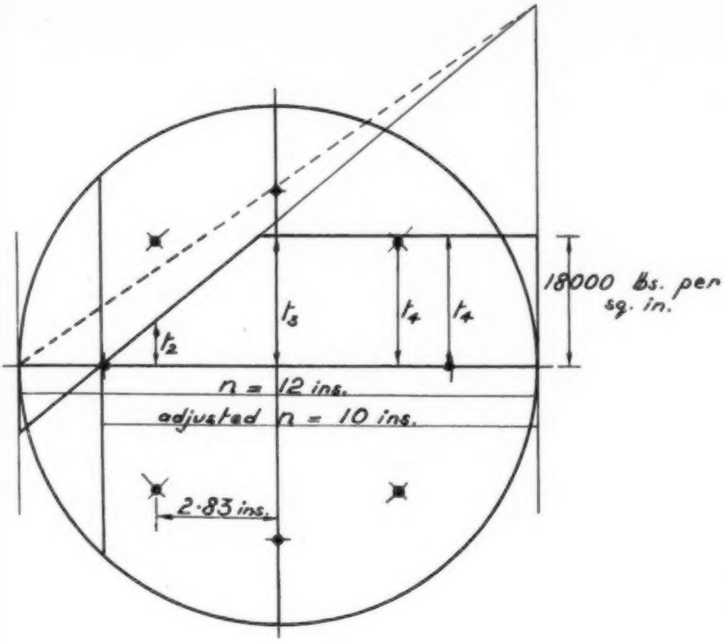


Fig. 5.

ment is large, the value of n should be modified before the first stress-diagram for the reinforcement is drawn in order to reduce as soon as possible the amount by which the direct forces are out of balance.

If the load exceeds that which the whole concrete section could resist as an axial load, n must be initially equal to D, so that the neutral axis is at the edge of the section. When n is modified it may exceed D, if necessary, as the reinforcement must resist the whole moment and that part of the direct load in excess of the load resisted by the concrete. In such a case none of the reinforcement will be in tension, and the eccentricity will be small.

EXAMPLE V.—A circular reinforced concrete column is to resist a working load of 130,000 lb. and a bending moment of 125,000 in.-lb. If c equals 1000 lb. per square inch and the diameter of the column is 12 in., calculate the reinforcement required, using mild steel bars with $1\frac{1}{2}$ in. (minimum) cover. If eight bars are arranged with their centres 2 in. from the surface, the maximum permissible load on the concrete is $1000 \times 144 \times 0{\cdot}588 = 84{,}750$ lb., $E = 0$, and $N = 1$. Reduce n from 12 in. to 10 in., and draw a stress-diagram for the reinforcement as shown in *Fig.* 5.

$$N = \frac{10}{12} = 0{\cdot}834, \text{ therefore } K = 0{\cdot}523 \text{ and } E = 0{\cdot}05.$$

The load on the concrete $= 1000 \times 144 \times 0{\cdot}523 = 75{,}300$ lb.
The bending moment on the concrete $= 75{,}300 \times 0{\cdot}05 \times 12 = 45{,}100$ in.-lb.

The moment on the reinforcement = 125,000 − 45,100 = 79,900 in.-lb.

$$A \times \Sigma at = A(4 \times 18{,}000 + 2 \times 2{\cdot}83 \times 12{,}000)$$
$$= A(72{,}000 + 68{,}000) = A \times 140{,}000.$$

Therefore $A = \dfrac{79{,}900}{140{,}000} = 0{\cdot}571$ sq. in.

The internal forces are:

$$\text{Compression in concrete} = 75{,}300 \text{ lb.}$$
$$\text{compression in steel} = \left.\begin{array}{r} 5 \times 0{\cdot}571 \times 18{,}000 \\ 2 \times 0{\cdot}571 \times 6000 \end{array}\right\} = 58{,}200 \text{ lb.}$$
$$133{,}500 \text{ lb.}$$

This is sufficiently close to 130,000 lb. to be acceptable. Therefore eight bars, each 0·571 sq. in. in area, would be suitable.

FIFTY YEARS AGO.

From "Concrete and Constructional Engineering", March–April, 1908.

The Concrete Institute.*—It is with great pleasure that we are able to announce that The Concrete Institute has now been formed, with a nucleus of one hundred founders, and although the official particulars as to constitution, officers, etc., are still in the confidential stage, we do not think we shall be indiscreet in stating that to our knowledge the Institute is eminently representative of the professions and industries concerned, and that it will have a Council that should do credit to the subject. A most interesting feature we believe is that an important proportion of the founders are members of the Institution of Civil Engineers, and hold public appointments.

Research.—It is, perhaps, regrettable to have to confess that so much of the information embodied in the Report† had to be sought for outside the confines of the British Empire; but, curiously, we cannot yet boast of possessing the necessary means and appliances at our seats of learning which are considered the essential equipment of the universities and technical colleges on the other side of the water for the investigation of structural materials and systems of construction. We have thus been dependent to a great extent on the labours of our American cousins for the information and data which have been incorporated in the Report, and which have been carefully compared with similar experiments on the Continent. This want of both the necessary funds and the properly equipped installations for the purposes of research in matters appertaining to engineering and building construction is greatly to be deplored, and seems to reflect upon the great public departments of this country, who are in this respect lagging behind the example of our more enterprising rivals in the competition for commercial supremacy.

[From "Concrete and Constructional Engineering", January, 1956.—"The rate of increase in the use of concrete in Great Britain in the past fifty years has probably been as great as in any other country, but, as has been previously mentioned in this journal, the contribution made by this country to the technical development of the material has been lamentably insignificant. It seems that every advance during this period has come from abroad."]

* Now the Institution of Structural Engineers.

† R.I.B.A. Report on Reinforced Concrete, 1907.

A Quay in Scotland.

THE deep-water berth at the ship-breaking yard at Inverkeithing accommodates ships of up to 35,000 tons displacement with a draught of about 30 ft. and has been extended to provide an additional working platform 200 ft. long at the end of the existing berth and a jetty to carry a movable crane of 10 tons capacity with a 120-ft. jib (*Figs.* 1 to 3). The jetty is 40 ft. long by 50 ft. wide and its head is 99 ft. from the shore. Crane tracks 155 ft. long are provided.

The ground comprises a layer of soft silt the hardness of which increases with depth until rock is reached. On the landward side of the low-tide line the depth of silt varies from 1 ft. to 13 ft.; on the seaward side the rock slopes at an angle of 45 deg. for a distance of about 40 ft. and then becomes nearly level. No piles were driven in the area where the rock slopes steeply.

The working platform is supported on piles driven at the top and bottom of the rock slope. The platform consists of prestressed precast beams supported on prestressed precast piles. The jetty is of reinforced precast beams and slabs cast in place and resting on prestressed precast piles. The crane tracks on the jetty and working platform are carried on the beams. None of the precast members weighed more than 7 tons.

The landward part of the site along the line of the existing berth was first filled with quarry waste. On the northern and eastern sides the filling is retained by steel sheet piling. On the western side it is retained by an existing timber wall, and on the southern side by an irregular outcrop of rock.

To carry the working platform, 12-in. by 12-in. prestressed precast piles were driven at 10 ft. 6 in. centres behind the sheet piling, and 16-in. by 16-in. piles at 5-ft. centres at the foot of the rock slope. Reinforced concrete capping-beams were then cast over the piles; the landward beam also caps the sheet piling. The prestressed beams, varying in length from 40 ft. to 50 ft., span between the capping beams at 2 ft. 6 in. centres. Filling to a depth of 1 ft. 2 in. is provided on the platform to absorb the impact from heavy loads.

Fig. 1.—View of Jetty.

Each prestressed beam consists of a precast rib 3 ft. 2 in. deep with flanges 10 in. wide and a web 6 in. thick. Precast slabs 2 in. thick were laid between the ribs to provide a permanent soffit for the 8-in. deck slab. In this way the ribs became a series of composite T-beams. The reinforcement for the deck and projecting shear studs were cast in the precast elements.

The prestressing steel was post-tensioned by the P.S.C. one-wire system, twelve cables of four 0·276 in. wires being used in each beam. Six anchorages were formed in the end-blocks of the ribs and

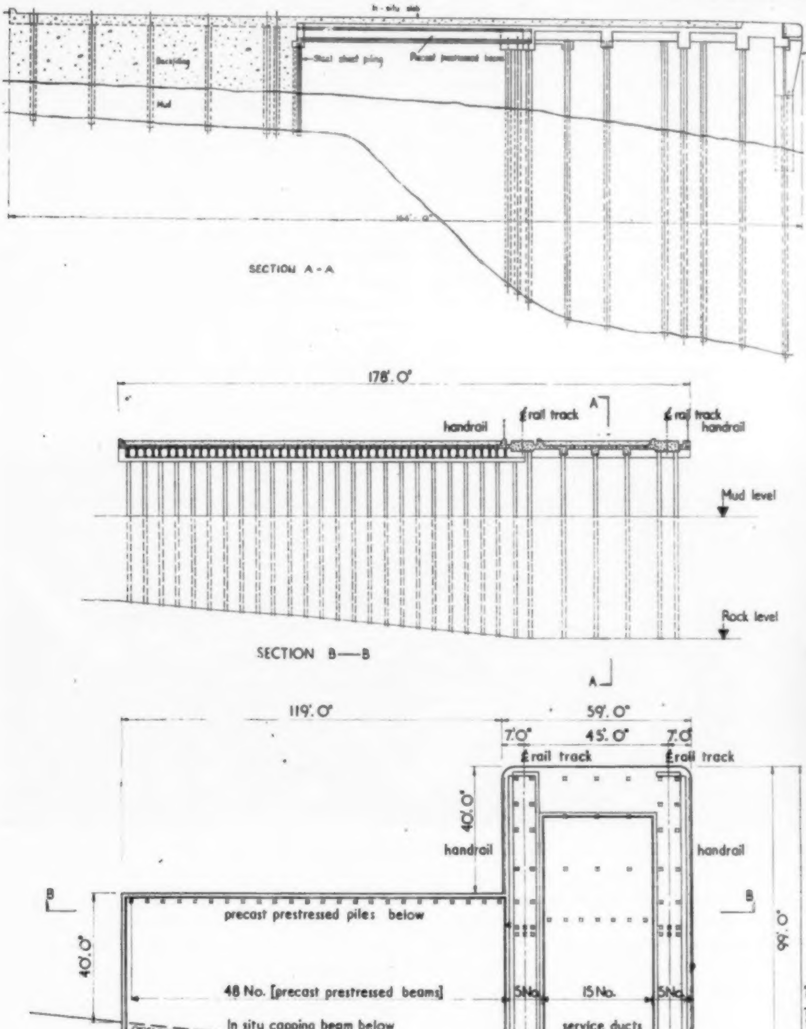


Fig. 2.—Arrangement of Quay.

six as castellations over the end 11 ft. 6 in. of the upper flanges of the ribs. Castellations were also formed over the remainder of the upper flanges to ensure a good connection with the deck slab. One-third of the wires were tensioned when test cubes had a minimum crushing strength of 5000 lb. per square inch, in order to withstand loads during the lifting and placing of the beams and the construction of the slab. When the slab was strong enough the remainder of the prestress was applied; this stress was designed to resist a live load of 5 cwt. per square foot.

About 70 ribs were required, and they were cast at a rate of between nine and twelve a week. A concrete casting bed was used, and side forms 50 ft. long were placed and removed by a derrick crane. The reinforcement for the ribs was prefabricated and lowered into the shutters by a crane. A concrete mixture of 1 : 1 : 2 by weight, with a water-cement ratio of 0·35, was used for the ribs; the aggregate was crushed granite with a maximum size of ¾ in. The compressive strength of cubes averaged 5000 lb. per square inch at three days and frequently exceeded 9000 lb. per square inch at 28 days.

Under the crane track the prestressed beams are at 1 ft. 10 in. centres and the thickness of the slab is increased to 1 ft.

The head of the jetty comprises precast reinforced beams and slabs supported on capping beams cast in place on 16-in. by 16-in. prestressed precast piles. The crane tracks are supported on reinforced concrete beams 7 ft. wide by 3 ft. deep cast within the head of the jetty and behind the sheet piling; this part is supported by 12-in. by 12-in. prestressed precast piles driven to rock.

An unusual and extensive fendering system (*Fig.* 4) is necessary since the jetty is used for the rapid breaking-up of ships. The fender is a continuous beam 4 ft. wide, 3 ft. deep, and 59 ft. long, and is designed to move horizontally as a flexible unit under impact. The face of the concrete is covered with steel to prevent abrasion by projections on the sides of ships.

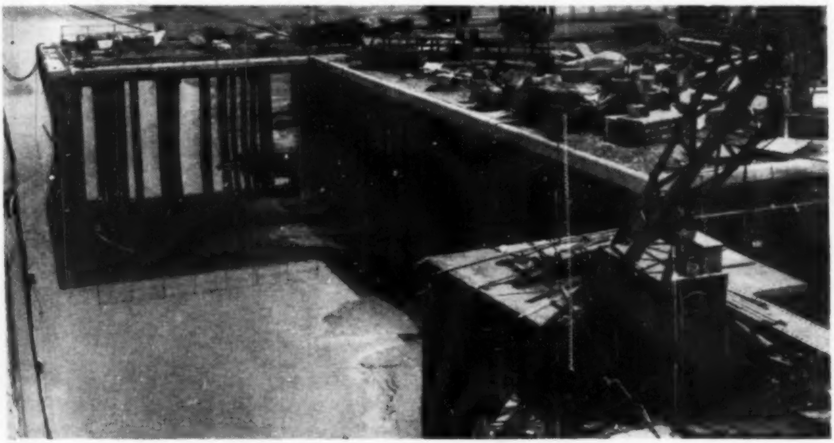


Fig. 3.—View of Working Platform.

The fender-beam comprises seven precast units, 8 ft. 6 in. long, prestressed on the P.S.C. one-wire system by four cables of twelve 0·276-in. wires. The joints between units are designed to be sufficiently flexible efficiently to utilise the energy-absorbing properties of 10-in. by 8-in. rubber blocks behind the beam.

The beam and the outer part of the head of the jetty are supported on seven 16-in. by 16-in. prestressed precast piles driven to rock. The piles are surrounded from 3 ft. below mud level to low-water level with reinforced concrete cylinders of

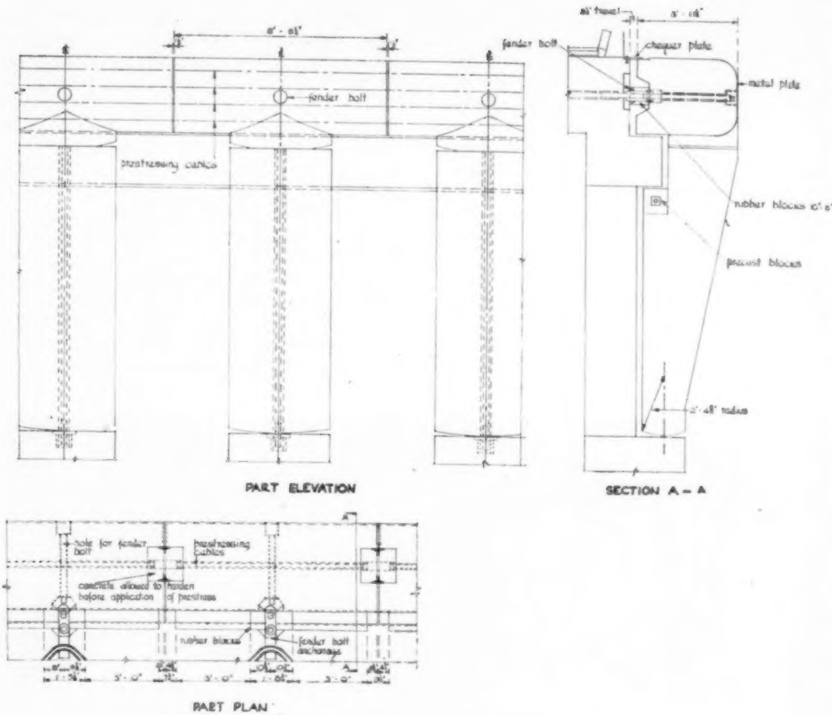


Fig. 4.—Details of Fenders.

4 ft. diameter. At low water level these cylinders are divided into halves; the rear portion rigidly connects the piles to the head of the jetty and the front portion supports the fender-beam through a pin-joint. The fender-beam is tied to the jetty by heavy chain-links so that the whole face of the jetty can move perpendicularly as well as parallel to the head of the jetty.

In order to avoid underwater concreting of the cylinders a concrete base 6 ft. high was cast on land in the form of a cylinder, the bottom of which was closed except for a central hole 18 in. square through which the pile could pass when the cylinder was lowered below water. A plywood cover was provided over the hole to retain 2 ft. of wet concrete in the cylinder until the pile was driven. This concrete formed a plug against the entry of water through the gap between the pile and the cylinder. A watertight cylindrical shutter was placed above the precast cylinder before it was lowered over the pile, and supported by a wire strap over the head of the pile. In this way, since the top of the shutter was always above water, concrete could be cast to the level desired.

The design and construction were by Messrs. Christiani & Nielsen, Ltd.

Information on Steel Shuttering.

A NEW catalogue issued by Acrow (Engineers), Ltd., of South Wharf, London, W.2, includes data and tables for the preparation of designs and drawings for steel shuttering and scaffolding. The contractors' plant also illustrated and described includes mechanical-handling plant, cement silos, concrete buckets, air compressors, bar-bending and cropping machines, and sawing machines.

Standards of Knowledge.

PROFESSOR H. N. WALSH, M.E., D.I.C., M.Inst.C.E.I., A.M.I.C.E., formerly Professor of Civil Engineering at the University of Cork, writes as follows.

The Editorial Note in your February number could prove so misleading to many people that I am impelled to offer the following comments.

Your remark that an employer may be misled if he accepts degrees and memberships of professional institutions as a substitute for his own judgment of the suitability of an applicant for employment may imply to many readers that degrees and memberships are of no use. A degree is a proof that a man has undergone a certain mental discipline and training to the satisfaction of his examiners. A degree may imply also that, as well as being trained to understand and apply fundamental principles, he has acquired a small amount of "knowledge" of engineering methods and materials. *It is no forecast of how he will develop.* In assessing graduates of some years' standing by a *suitable* oral examination the degree should be regarded as a necessary qualification, but no more than 5 per cent. of the possible marks awarded should be assigned to a pass primary degree or membership examination.

The report you quote of the Civil Service Commissioners states that many candidates fell short of the standard of basic technical knowledge implied by the qualifications they held. What is meant by "basic technical knowledge"? Is it memorized knowledge of materials and methods, or is it capacity to see and understand the basic principles involved in a problem with knowledge of where to find details of the materials and methods and properly to apply the principles and the knowledge acquired? In the first case many poor men might pass and many excellent men fail, but in the second case the good would undoubtedly show their real merit. The Commissioners apparently express the view that the possession of a degree or membership of a professional institution is not always a reliable indication of the suitability of an applicant. If they have just discovered that, they have "discovered" what has been known to university professors for very many years. It would also be interesting to know how the salaries offered by the Civil Service Commission compare with those offered in industry for men of similar ages and qualifications.

In forty years of university teaching in an engineering school I have met a very few men who could not be prevented from getting first-class honours and who would be unsuitable for many appointments. I have also met many men who just scrambled through their examinations and subsequently became engineers of very high quality—in some cases they reached eminence in their profession. A degree or membership of an institution is an object of unbounded ambition to some men; they will work themselves to the bone to get it, but having got it they will not open a book again. There are others of high ability who can get a degree quite easily; having got it they think they know everything necessary for their profession, in spite of being told otherwise, and, because they are so self-satisfied, they do not really study any more. Those who do well are those who, having got a degree either with difficulty or ease, realize that their useful "knowledge" is practically nil, but that they understand and can apply first principles, that they have been trained to acquire "knowledge" and to make use of that training in all the work they do to learn all they can about the work in hand. Whether the degree is a university degree or associate membership of an institution these principles apply.

Year after year I told my students at some stage of their course that when they got their degree they would know very little about engineering, but that they would understand certain fundamental principles and know how to acquire quickly from appropriate sources the knowledge necessary for their application, and that their success in their profession would depend on the amount of private study they did in the first five to ten years after graduating.

Service on many selection boards set up by the Irish Civil Service Commissioners and Local Appointments Board enabled me to meet many of my own graduates at anything up to twenty years after graduation. In a few cases I was shocked to find men who had promised

well disappointing from lack of study. But in many cases men who had disliked set studies and had scrambled through their examinations had developed an intense professional curiosity on graduation and had acquired a thorough understanding and knowledge of the branch or branches of the profession in which they had been engaged during the intervening years.

To a considerable extent neither the university course, university examination, nor institution examination makes much difference beyond excluding unsuitable candidates. It is the human nature, the natural ability, and character of the individual that determine subsequent progress or failure.

I think that any form of examination set by a professional institution for graduates either of a university or of the institution itself should be based on the work the men have done; it must necessarily be oral and should be designed to find out what benefit the men have acquired from their experience of design and works.

You suggest that university graduates can become associate members of an institution after two years' experience, one in an office and one on works. I wonder how many university graduates with two years' experience apply for associate membership. I would be inclined to think from my own experience that a minimum of four years would be much nearer the mark. Nevertheless, I am also satisfied that the right type of graduate can learn as much in two years as the man who is still struggling to understand fundamental principles can learn in five years.

Although many employers require that a candidate for employment must have a degree or be a member of a professional institution, I doubt whether any employer would assume that two men were of the same quality just because they were both associate members of the same institution. Take the case of two hypothetical graduates getting the same marks in their degree examination. One may be energetic, full of professional curiosity and drive, and find out everything he can about the work in which he is subsequently engaged. The other may be easy-going, incurious, perhaps lazy after he has obtained his degree, or he may suffer from some defect of health which will prevent him from putting much energy into his work. These men may enter similar types of employment, but one may be fortunate in getting very good training while the other might be left somewhat to his own devices. In two years' time these two men, who graduated equally, would have widely different professional knowledge and capacity. Between them there is a host of intermediate possibilities. No one but a fool would expect two graduates, who started apparently equal, to be equal in two years' time.

MR. K. V. S. KATHIRAMALAINATHAN, B.Sc., writes:

With reference to your February Editorial on Standards of Knowledge, it may be pointed out that University graduates should generally have three years' minimum practical experience, except those with evidence of one year of postgraduate study or research in which case it is two years as stated by you. Many internal graduates have, in addition, vacation training which is encouraged under the rules of the University department.

Among the questions posed by you the important one is about the suitability of candidates for engineering posts. I find it difficult to understand how one could accept without reserve the comment of the Civil Service Commissioners on candidates who "fell short of basic technical knowledge". A flair for interviews is, no doubt, very desirable for civil engineers, especially for executive and management posts, but surely to pronounce such a severe verdict on candidates who have already been fairly tested by a process of examinations (which, incidentally, cannot generally be passed by memorizing applied mathematics) and a professional interview there should be stronger reasons than their performance at a Civil Service interview. If examinations by educational bodies are considered inadequate tests of basic knowledge, is it logical to accept an examination by the Civil Service as giving a sounder guarantee?

When an employer stipulates that applicants for a post must be Associate Members of the Institution of Civil Engineers, without also stipulating that they have either passed Parts I and II of the examination or have been exempted from Parts I and II, he is inviting applications for the same post from men with different histories of education, training, and experience. Is this correct in principle?

Precast Concrete in a Church.

THE Church of the Holy Ghost (*Fig.* 1) at Bootle, Lancs, is about 130 ft. long, 66 ft. wide, 40 ft. high at the eaves, and 50 ft. at the ridge of the roof. The framework is of precast reinforced concrete.

The ground consists of silty sand of varying character and quality, interspersed with thin layers of peat. Bored in-situ piles were used in order to prevent differential settlement. The weight of the 11-in. cavity walls is transferred to the piles by precast wall-beams and columns, and by a foundation beam at the level of the pile caps which supports the first 10 ft. of brickwork and was cast in place. Pockets 18 in. deep were left in the pile caps for the precast columns; the pockets had a rebate 1 in. square at each corner to allow for easy grouting.

Each end of the structure is stiffened by casting in place the choir balcony at the narthex and the roofs and supporting columns of the sacristies. At the narthex a balcony was also cast in place to support the precast frames of the window (*Fig.* 1).

Precast frames at 14 ft. 3 in. centres span the nave. At the junction of the nave and the sanctuary (*Fig.* 4) the lower part of the framework was cast in place. Small prestressed beams span between this junction and the gable of the sanctuary and support short precast in-filling members. A concrete slab was cast on top of the beams (*Fig.* 2). The roof of the nave comprises precast prestressed trough-shaped units, with a suspended ceiling below them. Each frame in the nave is two-pinned. The columns are 47 ft. long, the dimensions at ground level being 21 in. by 9 in. and at the eaves 32 in. by 9 in. The weight of each column is $5\frac{1}{4}$ tons. The rafter is about 50 ft. long, 9 in. wide, 32 in. deep at the ends, and 28 in. deep at the ridge; the weight is 6 tons.

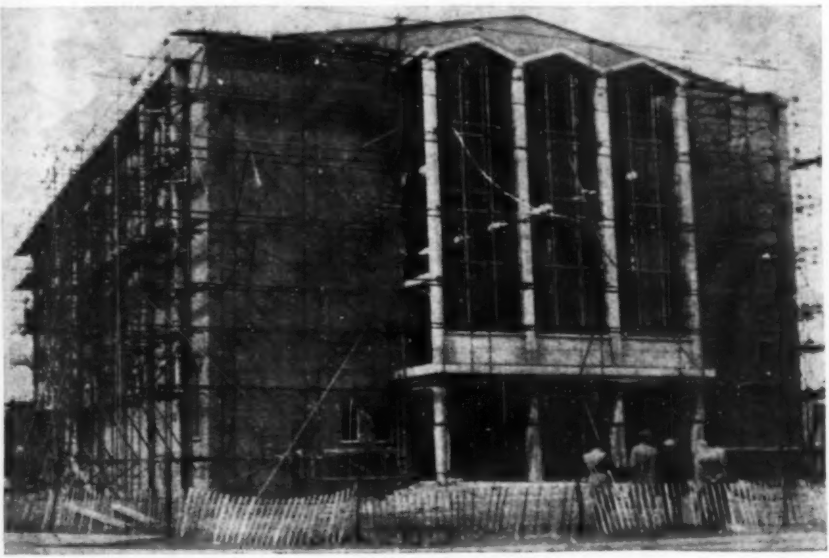


Fig. 1.—Church nearing Completion.

In order to obtain continuity between the three parts of each frame, and also to ensure easy erection, the columns are provided with brackets and projecting bars. The rafter was lowered on to the brackets, bars projecting from the rafter were welded to those projecting from the columns (*Fig.* 3), and the cavity was filled

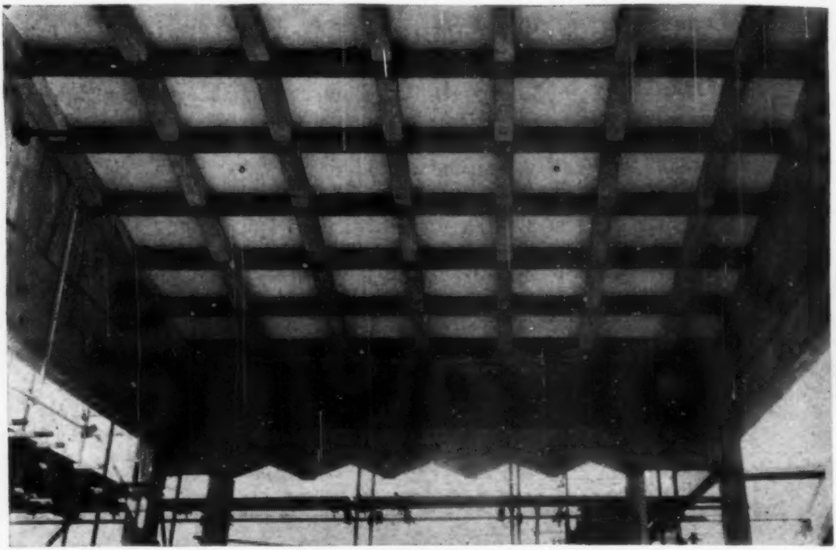


Fig. 2.—View of Roof.

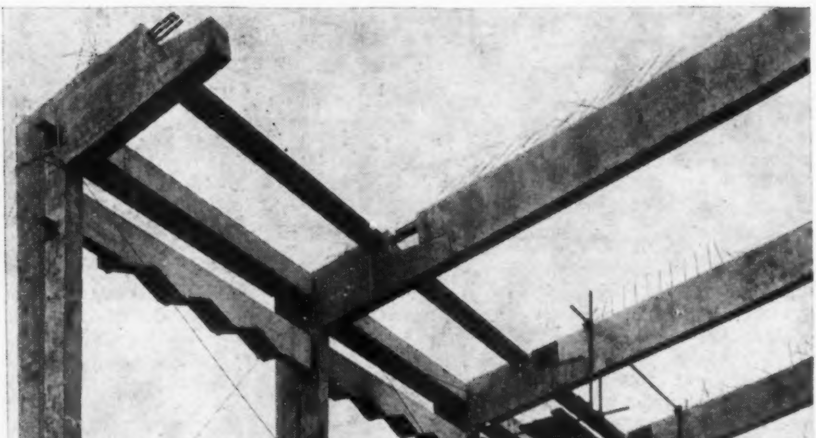


Fig. 3.—Junction of Columns and Rafters.

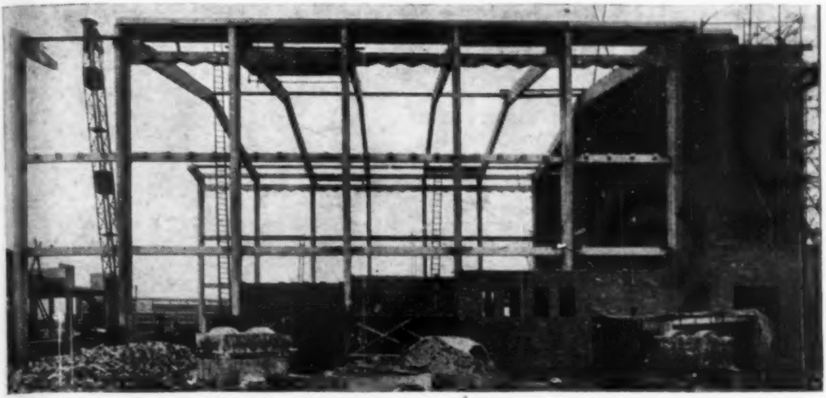


Fig. 4.—The Precast Frame.

with concrete made with high-alumina cement. The use of scaffolding was avoided by placing rolled steel channels at the ridge and eaves. These stiffened the frames during erection and provided a support for a working platform. The wall beams were placed in position on steel cleats, to which they are bolted. Bars were then threaded through a hole in the column, welded to bars projecting from the beam, and encased in concrete made with high-alumina cement.

The area of the nave is about 10,000 sq. ft. The cost of the foundations and the precast concrete was £18,000. The estimated cost of the completed church is about £90,000. The architects are Messrs. Weightman & Bullen and the consulting engineers are Messrs. Taylor, Whalley & Spyra. Messrs. John Williams (Liverpool), Ltd., were the general contractors, and the Cementation Co., Ltd., installed the piles. The precast concrete was supplied by the Liverpool Artificial Stone Co., Ltd., and erected by Messrs. McIntyre, Ltd. The prestressed roof units were supplied by the Fram Reinforced Concrete Co., Ltd.

Proposed Overhead Road in London.

The Ministry of Transport and Civil Aviation is considering the construction of an overhead road from Chiswick to Brentford, and Sir Alexander Gibb & Partners have been appointed consulting engineers to prepare plans. For the first mile the motorway would be over the Great West Road and supported on piers with splayed heads erected along the central strip of the road below. The new road would then diverge from the Great West Road, pass over a factory, and then descend to ground level; the total length of the viaduct would be 1½ miles and its maximum height 65 ft. The road would then continue at ground level to the junction with the proposed Slough–Maidenhead by-pass road; this part of the motorway will form a fast new route to London Airport, and direct connection with the airport would be provided by a branch road.

The length of the new road would be about 12½ miles. There would be two carriageways each 24 ft. wide, and on the viaduct there would be a central strip 4 ft. wide and a total width of 60 ft. The scheme includes twenty-nine bridges, ten of which would carry the motorway over waterways, three over or under railways, eleven over or under secondary roads and five at road junctions.

Travelling Shutter for the St. Lawrence Seaway, Canada.

A TRAVELLING shutter more than 100 ft. high is being used in the construction of the upper lock at Beauharnois on the St. Lawrence Seaway. The lock will be about 800 ft. long and 80 ft. wide between the gates and will accommodate ships with a draught of 25 ft. The walls will consist of thirty sections, each 82 ft. high, 40 ft. wide, and 38 ft. thick.

The shutter allows each of these sections to be concreted consecutively in a single lift, and is guided by the section previously cast. It consists of panels 12 ft. square supported on steel trusses, which travel on one rail near the top of the excavation and on two rails on the sill of the lock (*Figs.* 1 and 2). The panels consist of ¾-in. plywood supported on steel channels; these are adjusted and stripped by vertical and horizontal turnbuckles built into the main framework of the truss, and are in standard sizes so that they can be used later in conjunction with normal shuttering for other parts of the lock. The travelling frame is a bolted structure which can be modified for use on the main approach walls to the lock. It is anchored to the rock wall at the lower level by means of four 2¾ in. diameter rods about 45 ft. long and at a higher level by means of four similar rods which pass through the frame and clamp the two sides together. All the rods are covered with pipes so that they can be removed and re-used.

Only one bulkhead is required, as the concrete is placed against the preceding section. This bulkhead is similar to the main shutter, but the panels are supported by horizontal steel trusses.

After each section is concreted, the bulkhead is divided into three parts and moved to the next position by a crane. The travelling frame is pulled into position by winches mounted on bulldozers, and the front and back panels are aligned by the turnbuckles. The tie-bars are then inserted and the bulkhead connected at one edge to the travelling frame, the other edge being propped and wedged against the rock.

The concrete, which has a slump of 1½ in., is made with 5·8 bags (545 lb.) of cement per cubic yard, the maximum size of the aggregate being 3 in. It is

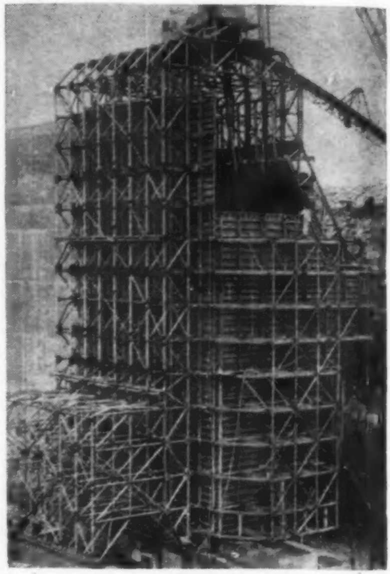


Fig. 1.—A Large Travelling Shutter.

hauled from the mixing plant in trucks of 4 cu. yd. or 6 cu. yd. capacity and dumped into a hopper on top of the rock wall. It is then conveyed to the top of the shutter and distributed through a bifurcated chute into hoppers which lead directly into trunks. A similar hopper and trunk mounted on top of the shutter are supplied by a crane. Metal chutes suspended from the cranked portion of the main frame at the level of the rock-ledge are also supplied by trucks of 4 cu. yd. capacity. The concrete is placed at the rate of 4 to 5 ft. per hour.

When the first 25 ft. have been placed concreting is suspended for eight hours to allow shrinkage to occur around a large water passage in the wall of the lock. At the 60-ft. level concreting is stopped for four hours while the shutters are erected for a gallery in the wall. No other interruptions of the concreting occur. The rate of progress expected is two sections in a week.

The shutter was designed and made by Acrow (Engineers), Ltd., of London.

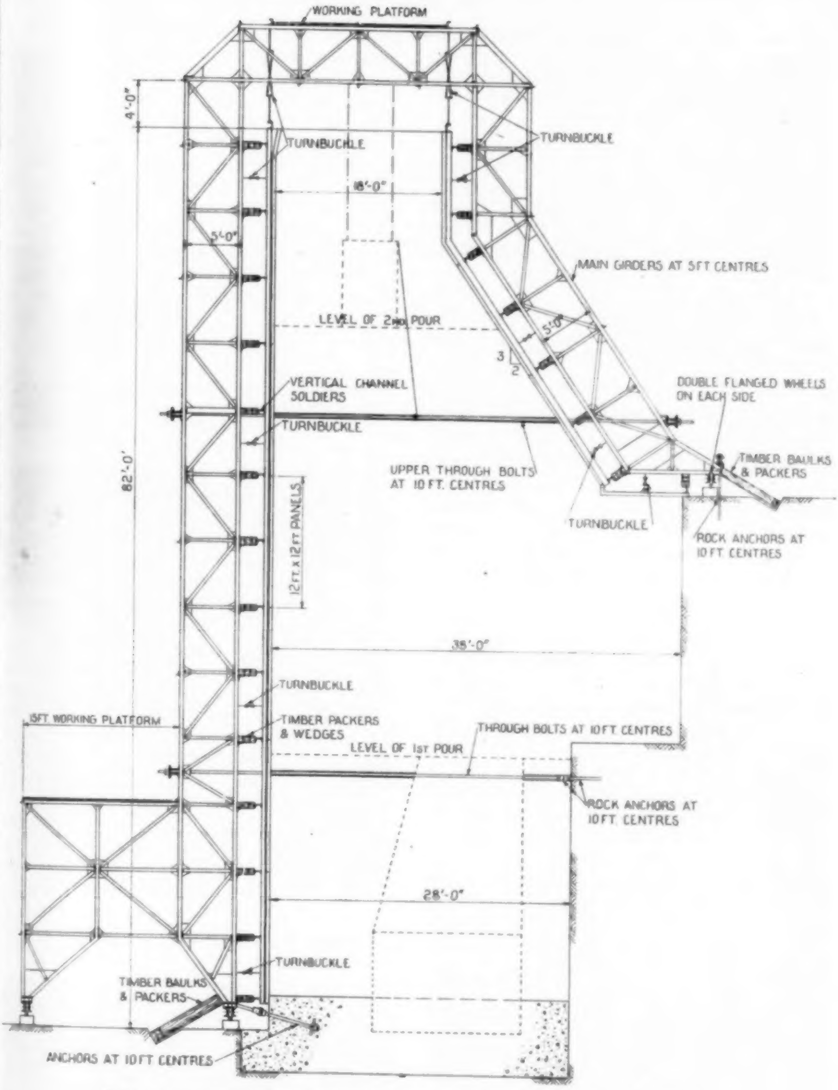


Fig. 2.—Travelling Shutter for the St. Lawrence Seaway.
(See facing page.)

Book Reviews.

"Tables for the Design of Beams and Slabs." By Jacques S. Cohen. (London: Concrete Publications, Ltd. Price 4*s.*; 4*s.* 2*d.* by post. 1 dollar in Canada and U.S.A.)

THIS is a reprint of an article which appeared in this journal for August 1957, together with an additional table, which enables any rectangular section to be designed by the load-factor method and the elastic method in accordance with British Standard Code of Practice No. 114, 1957.

[It has come to the Publishers' notice that these tables have been copied for use in offices and schools. This is a breach of copyright, and is forbidden.]

"Analysis of Multi-story Frames." By Gaspar Kani. (London: Crosby Lockwood & Son, Ltd. 1957. Price 40*s.*)

SINCE the publication of Professor Hardy Cross's method of moment distribution so many variants have been introduced that one is tempted to ignore another "new" method on the ground that it is probably a restatement of previously published work with but a minor algebraic transformation. Mr. Kani's method, however, is a useful addition to the multitude of books on the subject, for it simplifies the analysis of multiple-story frames in which the joints may be displaced horizontally as well as rotated. Moment distribution is not particularly suitable for such structures as some simultaneous equations must still be solved. The need for this has been avoided by Mr. Kani, and the solution of a frame with linearly-displaceable joints is as simple as for one in which the joints are fixed in position, although it is a little longer by reason of an additional iterative operation. For frames with non-translatory joints the method is very similar to the "moment balance" method introduced some years ago by Professor R. J. Cornish. The method is simple, repetitive, and amenable to a numerical check at any stage.

It is astonishing to the reviewer that there is still a prejudice against iterative methods and an impression that they are less precise than what were recently described as "theoretical" methods. This, of course, is untrue, for iterative methods may be carried to any desired degree of precision and their accuracy is limited only by the accuracy of the initial assumptions, upon which the accuracy of the "exact" methods also depends.

The book should not be ignored even by those who have a good knowledge of other methods of analysis, and it is certain that the method will be adopted by many in preference to the one they now use. To a certain extent the book is marred by the stilted English used by the translator; for example, such expressions as "the double of" could well have been written as "twice".—J. E. G.

"Indeterminate Structural Analysis." By J. Sterling Kinney. (U.S.A.: Addison-Wesley Publishing Co., Inc. London: Academic Books, Ltd. Price 76*s.*)

THIS book of 650 pages gives a full description of most of the mathematical, graphical, and experimental methods of analysing statically-indeterminate structures now available. The treatment is thorough and extensive, and the numerous examples help to make it an excellent reference book. It is also a good textbook, but in this respect it could be improved. The chapter on the history of structural theory could be usefully extended; the various methods of analysis are presented as separate subjects rather than as different aspects of the same subject; and some notes on such recent developments as the use of electronic computers, and the electrical analogy, would be interesting and helpful to students. A useful bibliography is included.

"Urban Motorways." (London: British Road Federation. Price 55*s.*)

IN 1956 an international conference was held in London to discuss the problem of easing the flow of traffic in cities, and the papers presented to the conference and the discussions are given in this volume. The principal features are the maps and photographs showing the use of "ring" roads, over-bridges, sunken roads, and intersections in many countries, and suggestions that have not yet been carried out for enabling traffic to travel faster in built-up areas.

Concreting Plant on Railway Trucks.

Erecting Masts.

A CONSTRUCTION train is being employed to erect the steel masts required in connection with the electrification of the main railway line from London to Manchester. The masts are erected at the rate of one every twelve minutes, giving a rate of progress of one track-mile in a working day of six hours.

The first portion of the train carries a boring machine which makes a hole to a depth of 10 ft. in less than two minutes. This is followed by a crane which places a steel mast into each hole and secures it in the correct position with a clamp. The last section of the train is used to mix the concrete and place it into the hole to form a foundation for the mast.

Fig. 3.

Fig. 1.

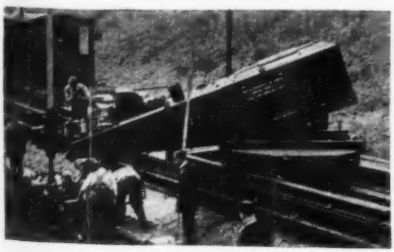


Fig. 2.

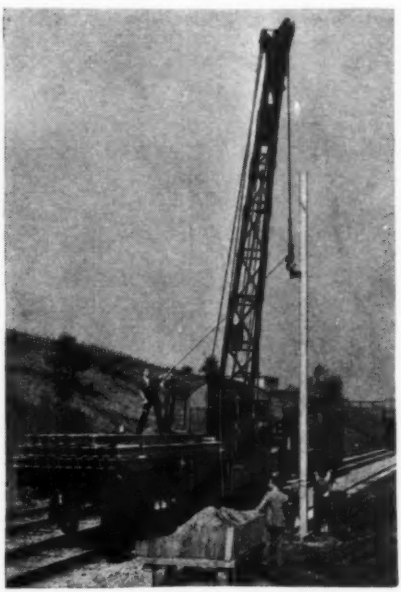


Fig. 4.

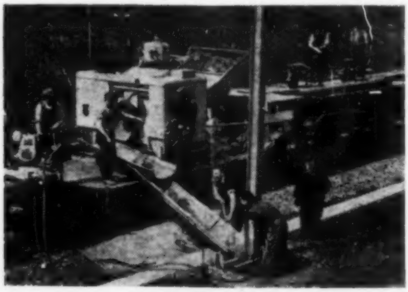


Fig. 5.

The sequence of operations is shown in *Figs.* 1 to 5. In *Fig.* 1, the auger of the boring machine is aligned with the setting-out peg, and *Fig.* 2 shows the machine at work. *Fig.* 3 shows the hole after lining, ready to receive the mast. The placing of the mast is shown in *Fig.* 4 and the concreting operation in *Fig.* 5. The boring machine and the concreting apparatus were designed by the British Insulated & Callender's Cable Construction Co., Ltd., in collaboration with the British Transport Commission.

Concrete Mixing Train.

A continuous mixer is being used by British Railways (London Midland Region) near Crewe. The train (*Fig.* 6) includes a wagon for carrying cement in a hopper of 12 tons capacity and sand and gravel in hoppers each of 50 tons capacity at one end, and a water-carrying vehicle at the other end. The sand and gravel are delivered to the mixer by conveyor-belts driven electrically from a generator-van also attached to the train, and the cement and water are then added. The concrete is delivered to a spout from which it can be placed directly where it is required or to a hopper from which it can be taken as required.

Fig. 6.—A Concrete Mixing Train.

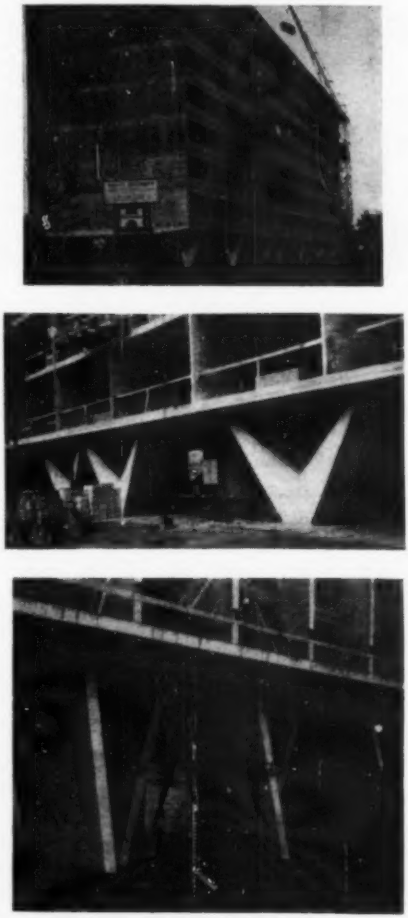
Construction Methods in Germany.

It is the custom for some of the members of the staff of Messrs. Wates, Ltd., to visit other countries each year. In 1957 the visit was to Berlin, and in the course of a long report on this visit a great deal of useful information is given, from which the following is abstracted by permission of the Company.

Cost.—The total cost, including finishes, of a concrete structure ten stories high comprising 64 residential flats was 3*s*. 5*d*. per cubic foot, including 1*s*. 8*d*. per cubic foot for the reinforced concrete frame and cross-walls and foundations. The cost of 1 : 1½ : 3 concrete in place in retaining walls was 76*s*. 6*d*. per cubic yard. Wooden shuttering to a retaining wall cost 6*s*. per square yard. Cement cost £10 per ton. Mild steel reinforcement cost £37 10*s*. a ton at the mill and £78 6*s*. a ton bent and fixed on the site. Wages per hour were 4*s*. 2*d*. for tradesmen and 3*s*. 2*d*. for labourers. The cost of labour for placing concrete in a retaining wall was 7*s*. 3*d*. per cubic yard. The work appeared to be first class. The average rate of placing pumped concrete was stated to be about 17½ cu. ft. per man-hour.

Cranes and Hoists.—Tower cranes, mostly of the luffing-jib type, were used on all multiple-story buildings. The travelling tower cranes were generally capable of lifting heavy loads to the tops of buildings of sixteen stories. Portable conveyors were in use on many sites, mainly for transferring excavated material to lorries. On a building of seventeen stories a hoist without a tower was in use, the cage being rotated on the floor slab at the required height ; this appeared to be an excellent machine, and to have advantages from the point of view of safety.

Precasting.—It appeared that precasting was favoured more in Berlin than in Great Britain. For one structure wall slabs 8 ft. 6 in. high by 4 ft. wide by 3 in. thick were precast in a vertical position. The first slab was cast between two shutters, one of which was mounted on rails. When this slab was sufficiently hard, one of the shutters was slid away, side forms for the next slab were put in position, a sheet of polythene was placed over the face of the slab already cast,



Methods of Supporting Mutiple-story Buildings in Berlin.

and another slab was cast. This process was repeated for the casting of further slabs. A special type of wallpaper which covered any irregularities in the face of the slab was applied directly to the concrete.

On another site wall slabs measuring 8 ft. by 5 ft. were cast horizontally one on top of the other, and separated by sheets of polythene. The number of stacks was such that a new slab was cast

on each stack eight hours after the casting of the previous slab. The work was done continuously by three shifts of concretors working eight hours each.

The walls of a block of flats seventeen stories high comprised an outer leaf of slabs measuring 12 ft. by 9 ft. by 3 in. thick with an inner lining of fibre-glass 1 in. thick and an inner leaf of concrete blocks; the space between the fibre-glass and the blocks was filled with concrete. Partition walls were cast horizontally, with the door frames in position and the surfaces finished ready for distempering.

FOUNDATIONS ON SAND.—The subsoil is sand, and at some sites this was consolidated by excavating to a depth of 10 ft. to 12 ft. and replacing the sand in 3 ft. layers, each of which was well moistened and rammed with a mechanical punner. It was claimed that this resulted in such a degree of compaction that it was difficult to dig the sand with hand tools. Machines were used to excavate for strip foundations and bases for columns, and the sides of the excavation did not need support. It was stated that the total amount of settlement of an eight-story structure on this type of foundation was only 4 mm.

FOUNDATIONS ON MARSH.—In the case of a block of flats eight stories high on a marshy site, the soft soil was removed to a depth of 10 ft. and replaced with sand. This was moistened and rammed, and then excavated to a depth of 3 ft. to receive the bases of the columns. When the structure was erected to the third story the settlement was 3 mm., and when it was completed the settlement was 4 mm.

PLANT.—Concrete mixers that were emptied by reversing the rotation of the drum were in general use. Concrete pumps were in common use, as were silos for the storage of cement delivered loose. In some precasting yards the concrete was pumped from the mixers to hoppers, from which it was distributed by skips carried by small cranes. Tower cranes were on rails, and some could cover buildings of seventeen stories. The largest could lift 1¾ tons at a radius of 100 ft. There were two control cabins, one at the top and one at mid-height. Scaffold-boards on the outside of a building were supported on scaffold-poles anchored to the concrete floors and cantilevered beyond the face of the wall. Handrails and toe-guards were provided. Elsewhere there was a considerable improvement in the form of hanging tubular scaffold used on the exteriors of reinforced concrete frame buildings. Prefabricated wooden shutter-panels measuring 5 ft. by 2 ft., faced with plywood, were generally used.

MATERIALS.—All the coarse aggregate used was crushed brick, delivered to the site in the sizes and gradings required. The price was up to 11*s*. a cubic yard. The fine aggregate was usually sand excavated from the site. Purchased sand cost up to 12*s*. a cubic yard. Cement was delivered mainly in pressurised vehicles. All the reinforcement was delivered in long random lengths and cut and bent on the site. Mesh reinforcement was delivered cut to the sizes required, and cost about £80 a ton.

Shuttering was generally of timber. Tongued-and-grooved boards dressed on one face cost 90*s*. to 95*s*. per square. The commonest form of shuttering was in the form of panels made of 2 in. by 1½ in. framing covered with 1 in. boards and hardboard, varnished on the face in contact with concrete. The hardboard was screwed to the boards. Wooden shutter panels could be purchased ready made. Undressed tree-trunks were often used for struts.

Scaffolding was generally of timber. Tubular-steel ladders of story height were commonly used; they had a hook at the top for hooking on to the scaffolding.

Very few bricks or clinker blocks were used; the clinker blocks that were seen measured 3 ft. by 1 ft. on the face.

High-alumina Cement.

A BOOKLET entitled "The Cement for Industry" describes the use of high-alumina cement to produce rapid-hardening, corrosion-resistant, refractory, and insulating concrete. The booklet is available free of charge from the Lafarge Aluminous Cement Co. Ltd., 73 Brook Street, London, W.1.

Fineness Modulus Method of Proportioning Aggregates.

By A. P. K. TATE, B.Sc., A.M.I.Struct.E.

THE report on aggregates[1] of the Institution of Civil Engineers recommends that the cumulative percentage by weight of the total sample retained by each of a specified series of sieves ranging from 1½ in. to B.S. sieve No. 100 (that is the fineness modulus) should be used for comparison with the requirements of specifications.

The fineness modulus of the material may be used to provide a quick and simple method of selecting proportions for an all-in aggregate. An optimum fineness modulus is selected corresponding to a grading giving satisfactory workability. The D.S.I.R.[2] has produced such grading curves for aggregates of 1½ in. to ¾ in. maximum size,[3] while similar curves for ⅜ in. maximum size have been published by the Cement and Concrete Association.[4] The values of the fineness modulus for these curves are given in *Table* I, together with values for theoretical curves based on the Fuller relation[5] for grading to produce maximum density, that is

Percentage passing each sieve

$$= 100\sqrt{\frac{\text{sieve size}}{\text{maximum particle size}}}.$$

TABLE I.—OPTIMUM FINENESS MODULI.

Maximum size	Published curves [3] [4]				Adjusted theoretical curves	
	(1)	(2)	(3)	(4)	$\sqrt[2]{\ }$	$\sqrt[3]{\ }$
1½ in.	650	604	556	505	600	556
¾ in.	575	544	504	460	516	479
⅜ in.	518	468	412	359	435	405

In order to utilise the Fuller square root curve in the limited range of sizes required, the values obtained are adjusted so that 98 per cent. of the aggregate is between the No. 100 sieve and the maximum size. Such adjustment compensates for the presence of the fine particles of cement in the final mass and gives curves approximating to the middle gradings of

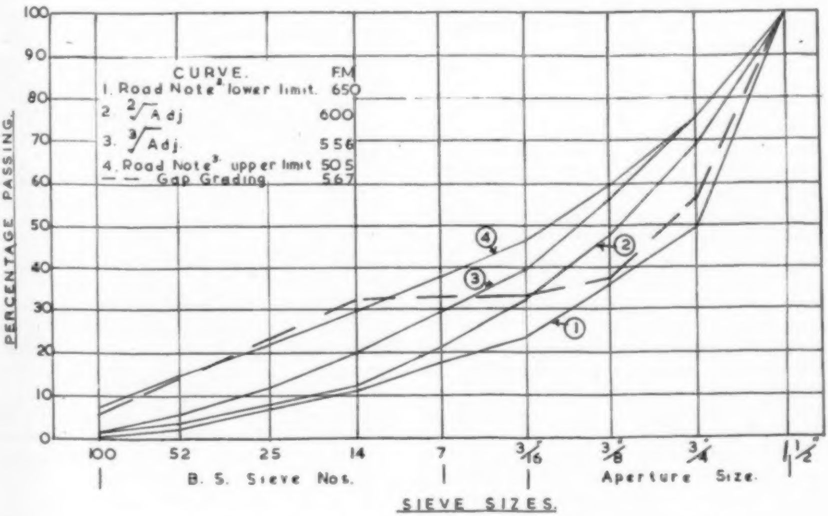


Fig. 1.—Grading Curves for 1½-in. Aggregate.

the publications of the Road Research Station and the Cement and Concrete Association, as is demonstrated for a 1½-in. aggregate in *Fig.* 1.

A more satisfactory grading may result from using a cube-root relation. Gradings for both these curves for ¾-in. aggregate are given in *Table* II.

TABLE II.—THEORETICAL GRADINGS FOR ¾-IN. AGGREGATE.

Sieve size	Percentage Passing			
	$\sqrt[2]{}$	$\sqrt[2]{\text{adj.}}$	$\sqrt[3]{}$	$\sqrt[3]{\text{adj.}}$
¾ in.	100·0	100·0	100·0	100·0
⅜ in.	70·8	68·6	79·3	74·8
$\frac{3}{16}$ in.	50·0	46·1	62·8	54·6
No. 7	35·4	30·5	49·8	38·7
No. 14	25·0	19·3	39·6	26·3
No. 25	17·7	11·5	31·4	16·2
No. 52	12·5	5·9	25·0	8·4
No. 100	8·9	2·0	19·8	2·0
Total $= X$	320·3	283·9	407·7	321·0
Fineness modulus $= 800 - X$	479·7	516·1	392·3	479·0

When two aggregates having fineness moduli F_1 and F_2 are mixed in proportions $(1 - p) : p$, the resulting aggregate has a fineness modulus of

$$(1 - p)F_1 + pF_2$$

in which p is the percentage of F_2 in the all-in aggregate. Hence if the sieve analyses of the available aggregates are known (for example F_1 and F_2), then the proportions in which they have to be mixed can be quickly obtained from the foregoing expression for any selected value of F from *Table* I (see example).

This method gives satisfactory results with normally steadily-increasing gradings, and it is suggested that it is an improvement on previous methods which use the amount passing one particular sieve (for example 24 per cent. finer than $\frac{3}{16}$ in. for all-in aggregate) as a criterion of suitable grading.

When unbalanced graded coarse or fine aggregates are used the method produces a gap-type grading for all-in aggregate similar to the dash-line curve in *Fig.* 1. So far as is known to the writer there is at present insufficient evidence to indicate any substantial correlation between fineness modulus and workability for a gap-graded aggregate. Consequently the fineness modulus should not be used for proportioning when either the fine or coarse aggregate fails to satisfy the British Standard limits for grading.[6]

As is demonstrated in *Fig.* 1 (dash-line curve) the fineness modulus cannot be relied upon as proof that an all-in aggregate is within certain grading limits. When, however, aggregate consisting of a limited range of sizes is considered the chance of pronounced gap gradings occurring with fineness moduli within the requisite limits is remote. Consequently the limits of fineness moduli corresponding to the B.S. gradings as given in *Table* III may be used as an indication of suitability. The fine and coarse aggregates producing the gap grading of *Fig.* 1 are also included in *Table* III. It will be noted that the fine aggregate is below the British Standard lower limit; this is confirmed when the grading curve is compared with the British Standard curve. In *Table* III the coarse limits refer only to 1½ in. maximum size.

TABLE III.—LIMITS FOR FINENESS MODULUS.

	B.S. limits[6]	Gap grading (*Fig.* 1)
Coarse (above $\frac{3}{16}$ in.)	690–765	718
Fine ($\frac{3}{16}$ in. and below)	220–360	179

More exacting limits (260–310) for the fine aggregate when a smooth surface finish is required are given by Troxell.[7] While these figures are for United States sieves, these differ only slightly from the B.S. sieves and the values of the fineness moduli are substantially the same.

Example.

Fineness moduli corresponding to coarse and fine gradings in *Table* IV, columns 1 and 2, are calculated as 662 and 261 (note the fine is within limits given in *Table* III). Selecting from *Table* I the optimum fineness moduli for ¾-in. aggregate as 500, then $500 = (1 - p)662 + p261$,
that is $401p = 162$, or $p = 40{\cdot}4$ per cent.

Final grading of this all-in aggregate with 40·3 per cent. " fineness " is given in *Table* IV, col. 3, together with the grading (col. 4) having a similar fineness modulus to curve 3, *Table* I (fineness modulus 504).

If an all-in aggregate were required having characteristics similar to curve No. 1, *Table* I (fineness modulus 575), then

$$575 = (1 - p)662 + p261,$$

that is $401p = 87$, or $p = 21 \cdot 7$ per cent.

The grading for this composite aggregate is shown in column 5 of *Table* IV, and that for the curve No. 1 in column 6.

TABLE IV.—COMPARISON OF GRADINGS IN EXAMPLE.

	(1)	(2)	(3)	(4)	(5)	(6)
3/4 in.	100	100	100	100	100	100
3/8 in.	31	100	59	65	44	45
3/16 in.	7	100	44	42	28	30
No. 7	0	92	37	35	20	23
No. 14		76	31	28	17	16
No. 25		48	18	21	10	9
No. 52		20	9	5	5	2
No. 100		3	2	0	1	0
Σ	138	539	300	296	225	225
F.M.	662	261	500	504	575	575

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(1) A review of the methods of testing aggregates for structures other than roads and airfield runways. Proceedings I.C.E. May 1955.

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(3) Road Research Laboratory. Design of Concrete Mixes. D.S.I.R. Road Note No. 4. 1950.

(4) J. D. McIntosh. The workability of concrete mixes with 3/8-in. aggregate. C. & C.A. Research Report No. 2.

(5) W. B. Fuller and S. E. Thompson. The laws of proportioning concrete. Trans. Amer. Soc. Civ. Engrs., 1907, **59**, 67–143.

(6) Methods for sampling and testing mineral aggregates, sands, and filters. B.S. No. 812, 1951.

(7) Troxell and Davis. Composition and Properties of Concrete. McGraw Hill.

A New Type of Composite Section.

THE section shown in *Figs.* 1 and 2, when used in conjunction with a reinforced concrete floor or wall, is designed to use less steel than a rolled steel joist to carry the same load. The design is based on the principle that when the compressive flange of a steel joist is embedded in concrete it does little work; this flange is therefore replaced by a round steel bar bent to a helix and welded to the web of a tee section. When the concrete is cast the helix connects the concrete to the steel. The combined section may be used as a beam or a column, and it is claimed that up to 20 per cent. of the steel required for a steel-framed building may be saved by its use. Large tee-sections may be obtained by cutting through the web of a steel joist, or may be fabricated from plates. The system has been developed by Messrs. MacKay Bowley & Co., Ltd., of London.

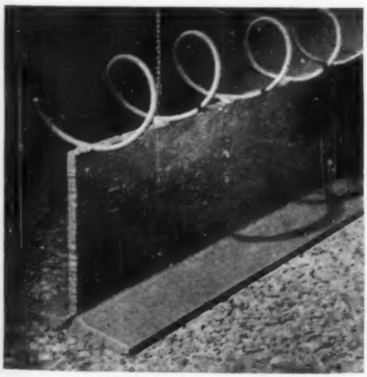

Fig. 1.

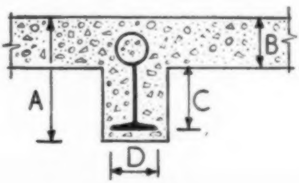

Fig. 2.

A Novel Form of Centering for Arches.

A NEW type of centering for arches that does not need shores has been devised by an Italian engineer, Dott. Ing. Eusebia Cruciani. In its simplest form the method consists of bending boards to the required curvature (*Figs.* 1 and 2) and fastening them together in this position by pieces of steel channel connected by bolts. The friction between the boards is relied upon to hold them in position, and it is claimed that curves can be accurately made and that they will have only a small deflection when loaded.

For long spans the clamped boards can be used as the upper and lower booms of a lattice girder braced by intermediate timber members (*Fig.* 3). In this case the clamps are U-shaped and joined by turnbuckles. The bolts are placed in the same inclined plane as the timber struts, which are therefore in compression and are not subjected to eccentric forces that might cause them to bend. More complex types of frames may be built in a similar manner

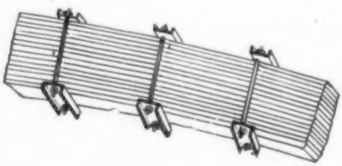

Fig. 1.

Fig. 2.

(*Fig.* 4); these frames are connected laterally by steel members and are cross-braced by steel cables.

The centering is usually assembled on the ground and erected by a cableway or

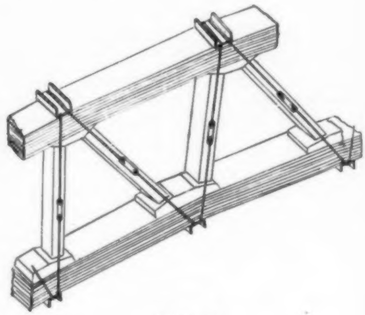

Fig. 3.

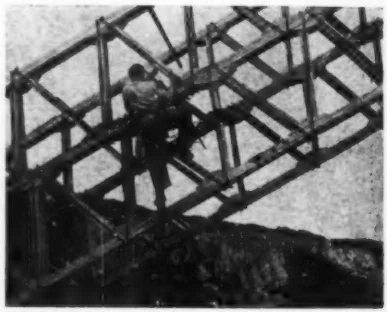

Fig. 4.

Fig. 5.—Centering for a Bridge in Italy.

Fig. 6.—Centering for a Bridge in Italy.

other means. In the case of very large and deep arches the lower part of the frame would be assembled on the ground and the upper part erected upon it. Examples of the use of the system are shown in *Figs.* 5 and 6. The inventor is represented in this country by Approved Inventions, Ltd.

Eighteen-story Flats in Southwark.

THE illustration shows a model of one of six buildings, each of 18 stories, now being built on the Brandon Estate, Southwark, for the London County Council. Each building will contain 64 two-bedroomed flats and have 4 penthouses, and will be 170 ft. high.

The framework and floors will be of reinforced concrete. On the elevation shown, the external columns will transmit

the loads from three stories to beams which span between the main cross-walls of the structure. The external walls will have a 7-in. cavity and the outer leaf will consist of precast concrete slats finished with exposed calcined-flint aggregate. The contract price is £1,138,343, and the work is expected to be completed in 1960.

Mr. Hubert Bennett is the Architect of the L.C.C., the consulting engineers are Messrs. F. J. Samuely & Partners, and the main contractors are Messrs. Wates, Ltd.

Travelling Scholarship for Architects.

A SCHOLARSHIP of £125 is offered by the Trussed Concrete Steel Co., Ltd., of Lower Marsh, London, S.E.1, to enable an Associate of the Royal Institute of British Architects to undertake a Continental tour of about three weeks' duration. The winner will be accompanied by a member of the Company's staff, and they will study concrete work on the Continent with particular reference to the collaboration between architects and engineers. Details may be obtained from the Company.

A Booklet on Steel Wire.

A BOOKLET on steel wires and wire ropes has been issued by British Ropes, Ltd., of Doncaster. The contents include tables of tensile strength and direct breaking strength, gauges, and conversion factors.

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